AB-16 - Paper

Test Battery for Selection of Missile Gunners

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The purpose of this study was to find instruments to improve the selection of anti-tank (AT) and anti-aircraft (AA) missile gunners. 109 conscripts in AA and 56 in AT missile units were tested with a battery of eight computerised spatial tests at the end of their compulsory military service. Also, a personality inventory was administered, and test data from the enlistment were available as predictors as well. About half of the tested conscripts had been assigned to the job as a missile gunner, while the other half had been screened out following simulator testings during the first few months of their service. Criterion data, in the form of missile simulation results and rank orders were collected for all conscripts tested. Multiple regression results indicated that performance as an AA missile gunner could be predicted by a newly constructed spatial test combined with two personality variables. In the AT case, no single test predicted performance, but two variables in the personality inventory showed a moderate correlation with the criterion. The study should be repeated on subjects at enlistment or calling-up.

Anti-aircraft (AA) and anti-tank (AT) missile gunners in the Swedish armed forces are conscript soldiers. AA missile gunners are trained to operate the Swedish Bofors RBS 70 or RBS 90 missile system and AT gunners the Bofors BILL or the American TOW system. The conscripts are classified as missile gunners in the enlistment procedure, according to the matching of a job requirement profile with their results on a cognitive test battery, an interview aimed at assessing their personal stability, and assessments of their physical and health status.

As part of a complete review of all job requirement profiles and the entire classification system, the National Defence College was awarded a contract to investigate testing methods to improve the selection of soldiers to "especially demanding jobs". Examples of such jobs are combat boat drivers, tank crews, and missile gunners. The missile gunner was chosen as subject for the pilot study summarised in this presentation. The purpose of the study was to investigate the predicitive power of existing tests presently not used for missile gunner selection by testing missile gunners and validating the test results against available job-related criteria.

METHOD

Sample

109 AA and 56 AT conscript gunners, all male and between 20 and 22 years of age, were involved in the study. They had some three weeks left of their compulsory military service when they were tested. About half of the soldiers in both groups had been assigned to the job as a missile gunner, while the other half had been assigned to other jobs in the missile unit. All of them had, however, had some training for the job as a missile gunner as part of selection procedures during the first few months of service.

Job analysis

Limited job analyses were carried out in the form of interviews with expert officers and conscript missile gunners at two Anti-Aircraft regiments and one Mechanised and three Infantry brigades. Field exercises were followed in order to get an understanding of the ways the different missile systems work, their tactics, and the nature of their demands on the gunners. The tracking task is similar in all the systems, the gunner keeping a hairline cross on the target until the missile impacts. The analyses showed that the task in the two *AT systems* is much the same, the main difference being that the range of the TOW missile is some 1500 m longer than that of the BILL missile. The gunner's tracking task was estimated to be a fairly easy one, while a more difficult task would be to estimate target availability, i.e. to make the decision wether to fire or not. This decision rests on estimations of target distance (closely related to missile flying time), target speed, and time available before the target will disappear because of terrain formations (e.g. a forest edge). In essence, the task is to compare two estimated time intervals: missile flying time and time needed for the target to drive into cover.

The two *AA systems* put higher demands on the gunner. Having acquired the target visually he has to estimate its range, speed, heading, and attitude in order to decide if it is within the firing envelope or not. Tracking is also demanding, since time pressure is high and target angular velocities can be very high at the end of an engagement. In the almost 30-year-old RBS 70 system the gunner in addition has to perform simultaneous gross and fine-tuned psychomotor coordination.

The conclusion drawn from the job analyses was that since many of the tasks require perceptual judgements, probably most would be gained by trying more tests of spatial ability than is used at present. Also, several of the interviewed officers pointed out the importance of personality traits such as emotional stability and social maturity. Therefore, a personality inventory was added to the test battery.

Instruments

Enlistment tests

From the enlistment procedure the results on 3 verbal, 5 spatial and 2 inductive tests from the Swedish Enlistment Battery (CAT-SEB) were available. Cronbach's Alpha for the tests varies between .70 and .85, with a mean of .81. The test results are summarised in a measure of general intelligence (G). The tests and the enlistment procedure are described by Mårdberg and Carlstedt (1998).

Also, two ratings from the enlistment interview were available. Leader ability (LA)

is rated for 60% of the population (those with stanine 5 or higher on the G factor), and concerns the ability to fulfill conscript officer functions in the military. LA essentially is an estimate of the conscript's mental stability and ability to take initiatives. Psychological functioning (PF) is rated for all conscripts and mainly concerns ability to handle strenuous situations in the military. The correlation between LA and PF is high, around .75.

The actual values of G, LA, and PF in the sample are shown in Table 1. As evident from the table, enlistment data could not be retrieved for all subjects.

Table 1. Means and standard deviations of G, B, and PF

	n	M	Sd
G	84	4.87	1.44
LA	46	4.76	1.16
PF	84	**5.32**	1.13 (Bold = p < .05)

Population mean and standard deviation for all three variables are 5.0 and 2.0 respectively. The sample is somewhat lower than the population on G and LA, and higher on PF.

Additional spatial tests

In addition to the already existing enlistment test results, eight additional spatial tests were administered to the gunners at their training sites. Three of these, called Patterns, Rotation, and Dots, are normally used in a test battery for selection of officers (Carlstedt & Widén, 1997). A fourth test, called Missile Gunner, was constructed for this study. These four tests are group-administered and are a combination of computerised and paper-and-pencil tests; the instructions and items are produced by a computer and projected onto a wall screen, and the testees' responses are recorded on ordinary answer sheets.

In *Patterns*, a pattern of black dots is shown for five seconds. The pattern is removed and five response alternatives are shown from which the testee has to choose the one with the correct pattern of dots. Cronbach's Alpha = .59.

Rotation requires the testee to identify which, if any, of three objects rotated in three dimensions that is/are identical to a target object. Alpha = .73.

In *Dots*, a circle filled with white dots, where some dots have been blackened to form a pattern, is shown for five seconds. The pattern is removed, and a new circle with white dots only is shown with arrows showing how to move the dots that were black in the original pattern to other places and how to rotate the (now imaginary) pattern. The changed and rotated pattern is to be recognized among five response alternatives. Alpha = .80.

Missile Gunner depicts a situation where a tank is moving over an open field delimited by two forest edges. First, a missile trajectory to the forest edge is shown, and then the tank traverses the field towards the edge. The task is to compare the time the tank spends to pass the field with the time the missile spends to impact in the forest edge. If the time for the missile is shorter it should be fired, otherwise not. Alpha = .47. (The low Alpha is probably caused by too many items being too easy. This was the first tryout of the test).

Also, four individually administered computer-aided tests were given, two of which have

dynamic tasks (Hit and Cloud), and two, more static tasks (Labyrinth and Copy). These four tests had been tried out at the enlistment, but were then not used for selection.

In *Hit*, the task is to "shoot down" an object moving horizontally from left to right on the PC screen at different speeds and in different sine waves with a "missile" positioned to the bottom right of the screen, moving straight up at constant speed and fired with a mouse click. Alpha = .55.

In *Cloud*, the testee has to predict the point in time when an aircraft will emerge from a cloud it has been seen flying into. The aircraft's speed is constant in one item but can vary between items, as can the extension of the cloud. The testee stops the (hidden) aircraft with a mouseclick and is given feedback after each item as to the position of the aircraft after having been stopped. Alpha = .76.

Labyrinth requires the testee to find his way through an imaginary labyrinth. He is presented with a series of two- or three-way crossroads where he can choose the way to go by clicking an arrow to get to the next crossroad. He has to remember waypoints that are "blind" so that he can choose a different path the next time he encounters that particular waypoint. In this way he must build a "cognitive map" of the labyrinth in order to reach the target.

Alpha = .72.

In *Copy* the testee is shown a line drawing for a few seconds. The drawing is then removed, and the task is to reproduce the drawing in a new pattern of lines as correctly as possible by clicking on appropriate lines. Alpha = .67.

Personality inventory

In addition to the test battery, a personality inventory (Commander Trait Inventory, CTI) of 155 items was administered (Carlstedt & Widén, 1998).

The inventory was evaluated over 11 scales and 5 factors, the latter briefly described in the following.

Leader Potential, High factor scores: For leadership optimal combination of different personality traits. High leadership motivation and high confidence in one's fast intuitive decision-making. Empathic ability and ideological value orientation. A high score *may* indicate a socially agreeable response set and an obviously beautyfying self-picture. *Low factor scores*: Cautious, bad self-confidence, not competitive, low interest for leading positions.

Inflexibility, High factor scores: Structures life through rational and systematic thinking processes. Sorts experiences and facts in concrete categories or in terms of models, theories and value systems. This leads to an inflexible and "square" way of handling life. *Low factor scores*: Attaches little importance to concrete facts or to systematizing and

evaluating experiences.

Adventureousness, High factor scores: Impulsive and little reflective. Strives constantly towards new sensory impressions and new experiences. *Low factor scores*: Cautious and orderly.

Opportunism, High factor scores: Egoistic superficial docility and adaptability in limited social environments. *Low factor scores*: Stubborn, uncompromising attitude towards the social environment.

Unreliability, High factor scores: Egocentric, ethnocentric and impulsive. Lack of empathy.

Low factor scores: Empathic and altruistic.

Criterion data

The primary reason for chosing the missile gunner as subject for the study was the expectation that quantitative data would be avilable in the form of missile simulation protocols from both AA and AT training sites. These would yield more reliable and valid criteria than is normally the case, when military grades and/or ratings by superiors are the only criteria available. As it turned out, however, different training sites had different routines as to the use and saving of these protocols. As a consequence, the criteria actually used consisted of ratings on a five-grade scale, based on quantitative simulation results for those soldiers appointed as regular missile gunners. Those who had been successively screened out were similarly rated, using simulation results as far as possible, and where such results were scarce or unavailable the soldiers were rated on a five-grade scale by the platoon commanding officer who had been in charge of the selection simulations, and who had acquired a thorough knowledge of his 30 soldiers during their 7-10 months of service. The criterion distributions were approximately normal for both the AA and AT groups.

RESULTS

Missing data

Due to technical problems during testing and to the fact that not all tested soldiers could be retrieved in the enlistment data files, missing data occur. The most cumbersome aspect of this is that enlistment data are missing, since the results show that one of these promises to be a predictor of AA gunner ability. As a consequence, the multiple regression analysis reported here had to be based on only a small sample (n = 29) in the AA group.

Table 2. Test variables having significant (p ≤ .05) correlations with the criterion in the AT and AA groups (CTI variables in italics)

Variable	AT group			AA group		
	_r_	_n_	_p_	_r_	_n_	_p_
Cloud				.22	76	.05
Hit				.28	107	.01
LA rating				.48	29	.01
PF rating				.28	54	.05
Cognitive Ability (G)				.31	54	.03
Sensation Orientation	.34	56	.01			
Intuition	.34	56	.01			
Superficial Value Orientation	.34	56	.01			
Empathy	.36	56	.01			
Leader Motivation	.32	56	.02			
Leader Potential	.40	56	.00			

In the AT group, only CTI variables correlate with the criterion, whereas in the AA group two tests and three enlistment variables but no CTI variables do so.

Multiple regression analyses

Multiple linear regression analyses were performed, using the stepwise interactive mode in Systat 7.0 for Windows. The results appear in Tables 3 and 4.

Table 3. Multiple regression of the criterion on predictors in the AT group (n = 56)

Predictor	_r_	_B_	_SE_	_β_	_t_	_p(2 Tail)_
Leader potential (CTI factor)	0.40	0.06	0.02	0.44	3.54	0.00
Opportunism (CTI factor)	0.21	0.03	0.02	0.28	2.22	0.03

$R^2 = 0.23$ (0.20 adjusted), $F = 7.67$, $p = 0.00$.

Table 4. Multiple regression of the criterion on predictors in the AA group (n = 29)

Predictor	_r_	_B_	_SE_	_β_	_t_	_p(2 Tail)_
Hit	0.28	0.16	0.06	0.40	2.74	0.01
Abstract Thinking (CTI scale)	0.15	-0.03	0.01	-0.40	-2.69	0.01
LA rating	0.48	0.35	0.14	0.37	2.45	0.02

$R^2 = 0.53$ (0.46 adjusted), $F = 8.20$, $p = 0.00$.

Attempts to find good predictors for the total material, i.e. predictors for the general job as a missile gunner, were ineffective. Also, attempts to substitute CTI variables for the LA enlistment rating in order to get a larger population in the regression analysis of the AA group were without success.

DISCUSSION

This study was performed in order to investigate possible ways to improve the selection of missile gunners. The concurrent validation results in disadvantages such as restriction of range. Also, some subjects had been trained on the job and others to some extent so, which means that training effects could have biased the results. The small samples resulting from missing data constitute a serious disadvantage. Therefore, the study should be repeated by testing subjects either at enlistment or at calling-up. Better criterion measures should be constructed. However, the study has given some valuable hints as to how to proceed in this next stage.

The new test "Hit" appears to have potential as a predictor for performance as an AA missile gunner, and should be further developed. Apparently, the AA gunner should not be an "Abstract Thinker", while mental stability and social capacity as measured by the rating Leadership ability seem to be important in his or her job.

In the AT group only personality variables proved to be able to predict gunner performance, albeit rather weakly. High Leadership potential, involving motivation to take on leadership and empathy towards one's own small group, and a certain degree of Opportunism, involving social capacity and a will to submit to authorities and follow the rules, seem to be characteristics that are important in the AT gunner's job.

The differences in predictors of performance on the two jobs seem rather logical. The AA gunner is something of a "lone wolf", working alone with a task that requires dynamic spatial ability and quick decisions. The AT gunner, on the other hand, works in a team with a task that demands more of thorough preparations and cooperation than of eminent spatial qualities, since his or her main task after firing the missile is simply to keep a hair-cross on a target that moves rather slowly as compared to the AA gunner's targets.

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